

WHAT IS CLAIMED IS:

1. A processing method for forming an insulated film on a surface of a substrate to be processed,
5 through an oxynitriding treatment, said processing method comprising the steps of:

nitriding a surface of the substrate by irradiating plasma containing nitrogen atoms onto the substrate; and

10 oxidizing the surface of the substrate, which has been nitrided, by irradiating plasma containing oxygen atoms.

2. A processing method according to claim 1,
15 wherein said nitriding and oxidizing steps place the substrate on a susceptor, a temperature of the susceptor being maintained at 600 °C or lower.

3. A processing method according to claim 1,
20 wherein said substrate include silicon, and said nitriding and oxidizing steps control a process time so that the insulated film has an effective oxide thickness of 3.0 nm or smaller.

25 4. A processing method according to claim 1, wherein said nitriding step uses, as process gas, gas that includes at least one of N₂, NH₃ and N₂H₄ or the

one which is diluted with at least one of He, Ne, Ar, Kr and Xe, mixed gas of $H_2 + N_2$ or the one which is diluted with at least one of He, Ne, Ar, Kr and Xe.

5 5. A processing method according to claim 1, wherein said oxidizing step gas uses, as process gas, gas that includes at least one of O_2 , O_3 , H_2O , and H_2O_2 or the one which is diluted with at least one of He, Ne, Ar, Kr, Xe and N_2 .

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6. A processing method according to claim 1, wherein said oxidizing step sets ion energy to be 5 eV or smaller incident to the substrate from the plasma.

15 7. A processing method according to claim 1, wherein said substrate includes silicon, and said oxidizing step controls an oxygen atom concentration so that a nitrogen atom concentration is 5 % or smaller at a position near an interface between the silicon and a
20 silicon oxynitride film in the insulated film.

8. A processing method according to claim 1, wherein said nitriding step controls a process time so that the insulated film contains the nitrogen atoms
25 between $3 \times 10^{14} \text{ cm}^{-2}$ and $1.5 \times 10^{15} \text{ cm}^{-2}$ that is converted into a surface density.